AS Unit 1: Basic Biochemistry and Cell Organisation

Name:	Date:

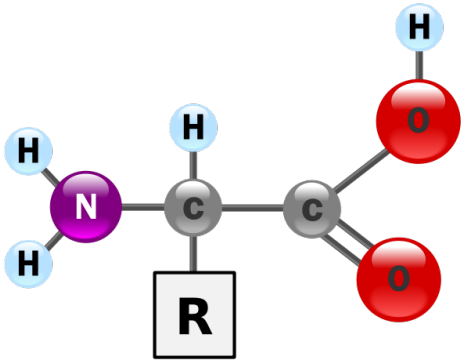
Topic 1.1 Biological Compounds – Page 5

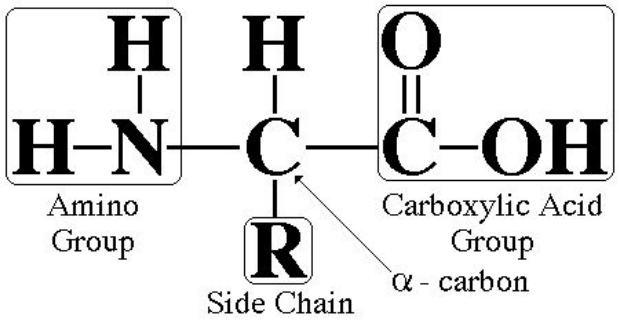
I. Proteins

		Completed
1.	Go through the PPT on Proteins	
2.	Read the following handouts: • 1.1P Levels of Protein Structure • 1.1Q Shapes of Proteins • 1.1R Protein Function • 1.1S Protein Notes	
3.	Complete the following: • 1.1Q Questions at the end of the hand out • 1.1S Diagram annotation and table at the end of the hand out • 1.1T Questions	
4.	Homework: Be able to draw and talk about the structure of the following: • Amino acid structure • Condensation and hydrolysis reactions • Dipeptides • Levels of Protein Structure • Protein functions	

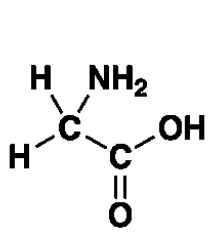
Introduction to Proteins

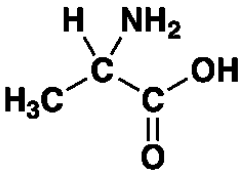
Amino Acids.
Amino acids are the building blocks for all proteins. There are 20 different amino acids found in the body, which can be polymerized into proteins. All amino acids have the same general structure the only difference between the different amino acids lies with their 'R' groups. This group is variable and it means there is a different type in each amino acid.

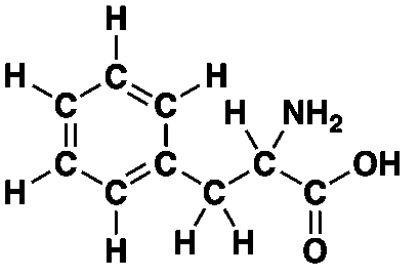


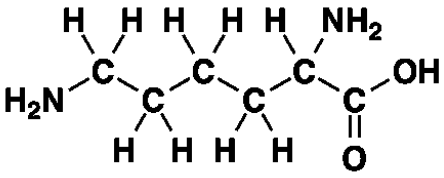


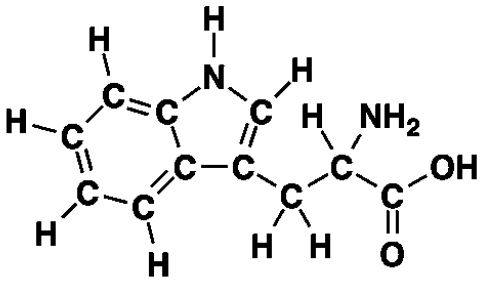
Examples of amino acids:

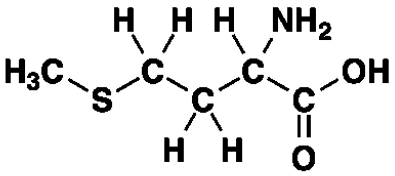

glycine

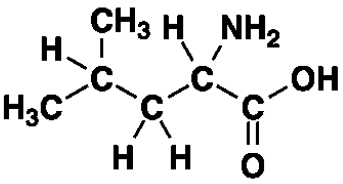

alanine

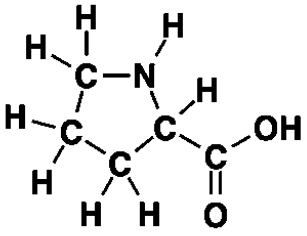

phenylalanine


lysine


tryptophan

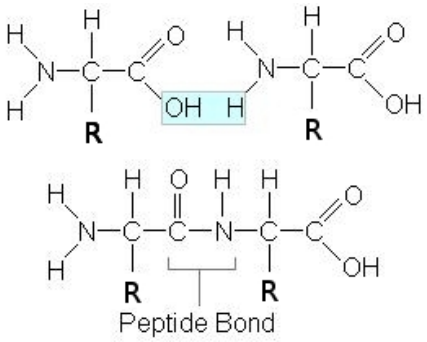

methionine


leucine


proline

For each, highlight the 'R' group.

If you can remember how two monosaccharides and fatty acids and glycerol can bond together, then the way in which amino acids bond will be very familiar. It is, once again, a condensation reaction with water being lost; the bond formed is called a **peptide bond**.



The reaction that has joined together two amino acids has formed a **dipeptide**. Further reactions form **polypeptides**. Polypeptides can be of varying lengths.

Amino acids can be linked together in any sequence. This makes for a huge variety of polypeptide molecules. Of course, the synthesis of polypeptides is not random, but dictated by and coded for by the genes of an organism. The mechanism of this will be covered in a future unit.

As the two ends of an amino acid (the carboxyl and amino ends) are used in the formation of peptide bonds, it is the variable 'R' group that determines the character of the polypeptide. In addition, the R groups form bonds between the polypeptide chains themselves giving rise to the particular 3D shape of the protein (tertiary structure).

When describing protein structure there are four levels that can be described, primary, secondary, tertiary and quaternary.

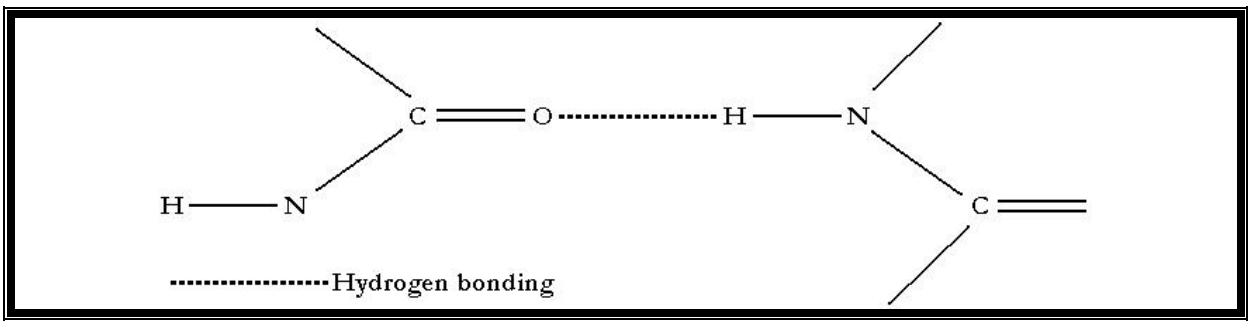
Primary Structure

The primary structure of a protein describes the type, number and sequence in which the amino acids are joined together in a protein molecule. Proteins differ from each other in the variety, numbers and order of their amino acids. There are an infinite number of different possible combinations. This structure forms the 'polypeptide backbone'.

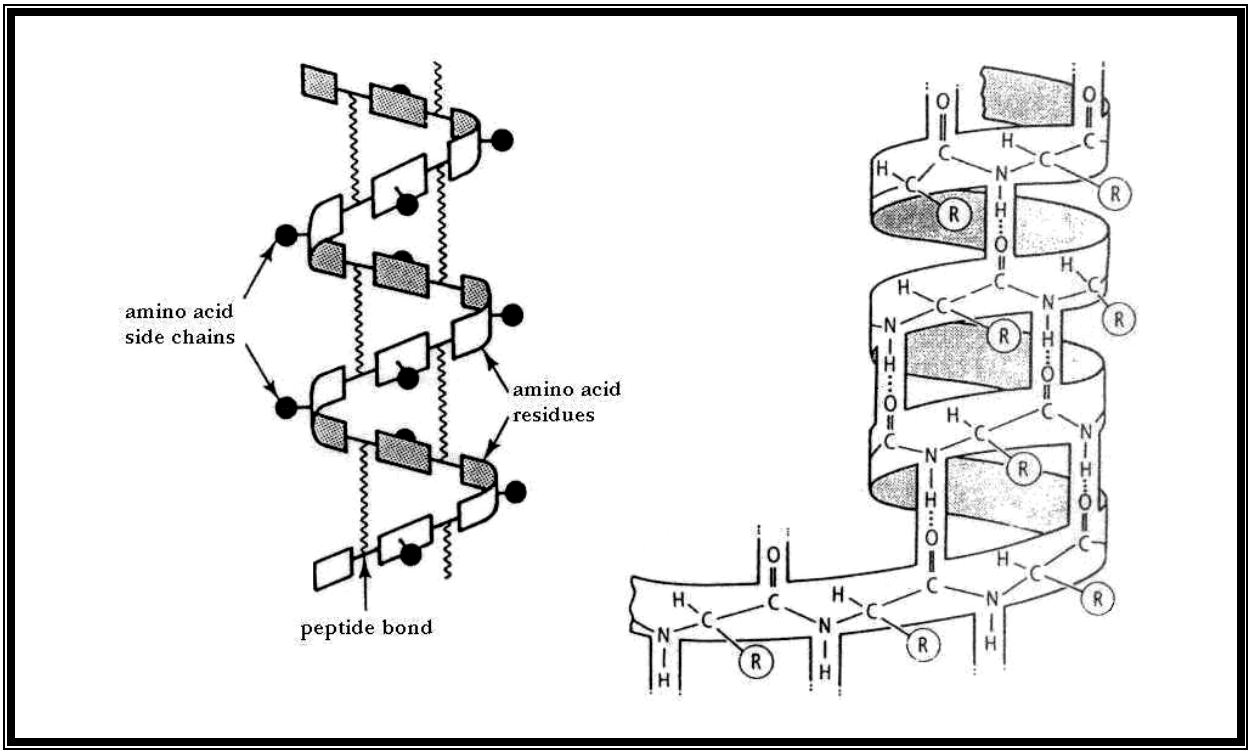
Significance of the Primary Structure:
Different amino acids have different 'R' groups, because of this the number and type of the amino acids in the primary structure will determine the final structure that the proteins takes and therefore its function.

Secondary Structure
The secondary structure of a protein is the way in which the polypeptide chain (backbone) is coiled or folded. There are two common forms of secondary structure either the chain is coiled like a spring to form an alpha helix, this is the most common form or lengths of the chain can line up side by side to produce a beta-pleated sheet.

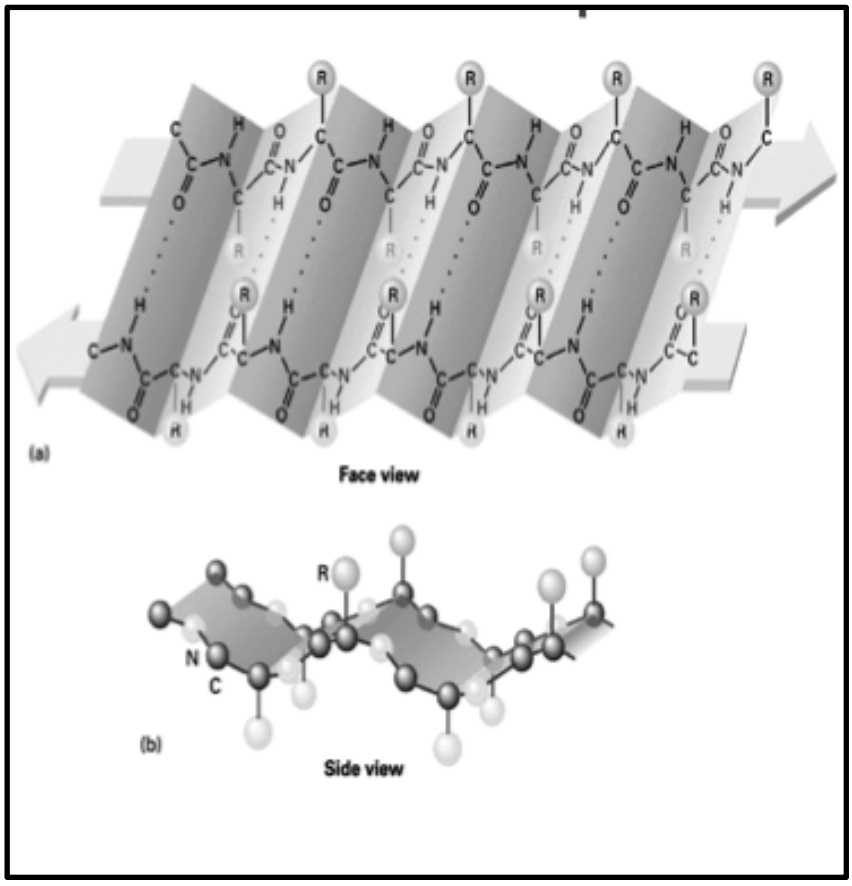
The secondary structure of proteins are held together by hydrogen bonds that form between
C = O and N – H groups.



Alpha – helix
Below are two diagrams that illustrate the alpha-helix structure:



Use highlighter pen to highlight all the hydrogen bonds across the helix that are helping to maintain and stabilize this shape.
(another common secondary structure is the beta pleated sheet)



Tertiary Structure

The tertiary structure of a protein is produced when the secondary structure is further folded and coiled. The tertiary structure is maintained by:

Hydrogen bonding as discussed in the secondary structure of proteins

Disulphide cross links between side chains containing sulphur groups –SH

—— S ..... S——

..... Attraction between sulphur groups

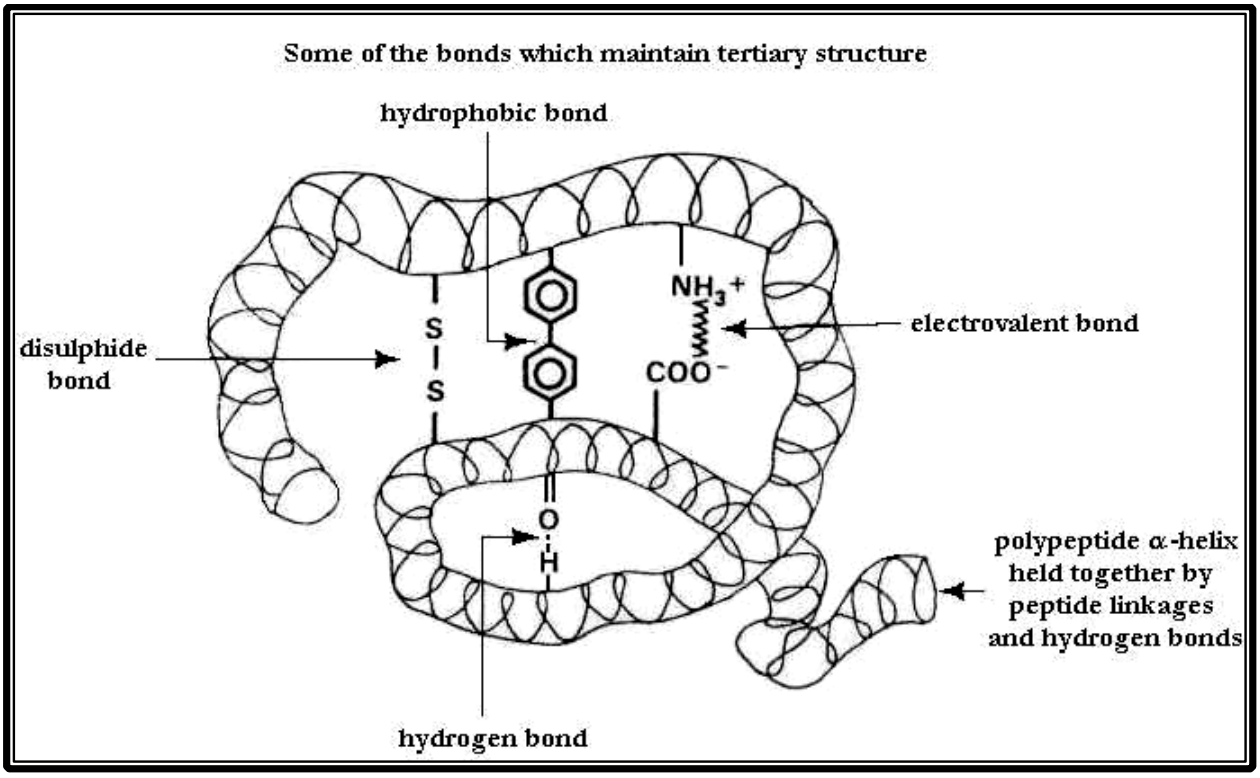
Ionic bonds between positive and negative ions found on the R group (sometimes called electrovalent bonds)

e.g.

——— CO_2^- ..... ^+H_3N ———

..... Ionic bonds

As well as hydrophobic bonds.



Many globular proteins have a well developed 3 dimensional, compact shape.

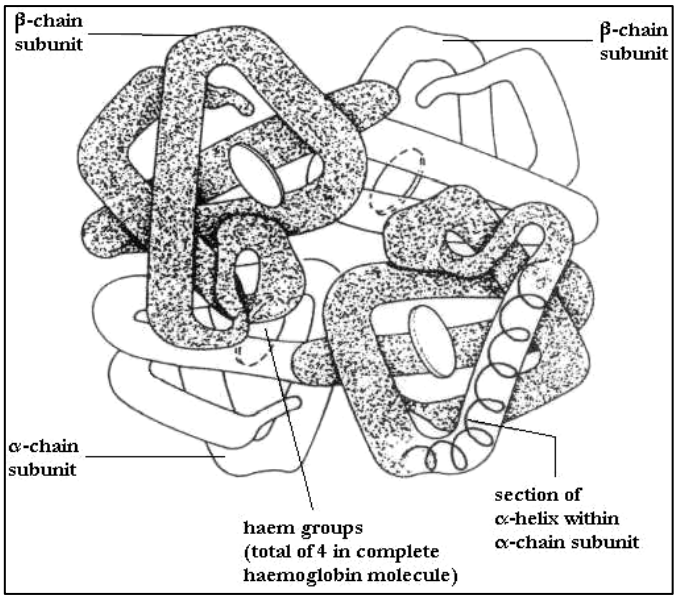
Significance of the Secondary and Tertiary structure:

The secondary and tertiary structure of a protein is collectively referred to as the higher structure of a protein. Some proteins will only have a secondary structure whilst others will adopt a tertiary structure. This shape is extremely important as functional proteins such as enzymes and antibodies rely on having an exact shape in order to function; structural proteins such as keratin depend upon an exact shape to give them their shape for strength.

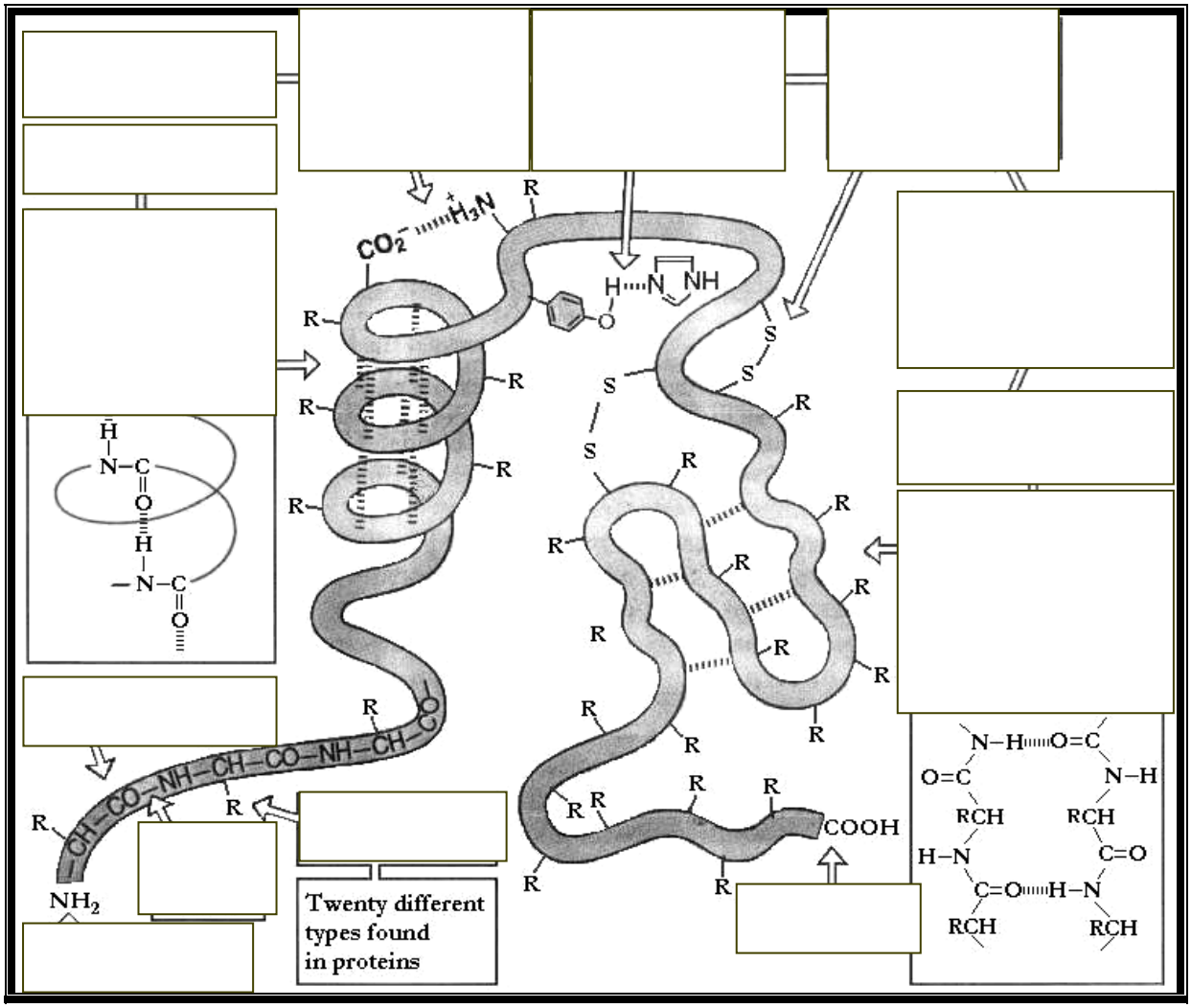
If a protein just consists of a single polypeptide chain then secondary or tertiary will be the final level of structure for that protein.

Quaternary Structure

If a protein is made up of more than one polypeptide chain (and may also incorporate a non-protein element) into its structure then it is described as having a quaternary structure.



Using the labels on the next page nnotate this diagram to summarize the structure of proteins:



N- terminal	Peptide bond	Amino Acid side chain	C-terminal	Primary Structure
Secondary structure	Alpha helix formed by twisting the chain into a coil and held together by hydrogen bonds	Ionic bonds between positive and negative side chains	Beta pleated sheets formed by chains lining up and held together by hydrogen bonds	Disulphide cross links
Tertiary Structure	Hydrogen bonds between side chains	Secondary structure		

Globular proteins, have a well-developed tertiary structure and form compact and rounded molecules. The polypeptide chains tend to have more irregular amino acid sequences. They are soluble in water. Most globular proteins are soluble in water.

Globular proteins form antibodies, enzymes, hormones and plasma proteins.

Fibrous proteins consist of long and narrow parallel chains of polypeptides with little tertiary structure. Primarily they are alpha helices linked into strands. The polypeptide chains tend to have repetitive amino acid sequences. They form physically tough insoluble fibers or sheets. Most are insoluble in water due to R group side chains that are positioned on the outside of the molecule being hydrophobic. They are involved in the structure of connective tissues, tendons, bone matrix and muscle fibers.

.

Function	General description of function	Named Example	Description of the job carried out by the named example
Enzymes			
Hormones			
Structural	Help form strong structures and frameworks within the body e.g. nails, hair, bone, cartilage and a framework to bind the cells of tissues together.		
Transport	Help to transport substances around the body in the blood.		
Protection	Help to protect the body the body from invasion by microorganisms either in clotting the blood or producing antibodies.		
Contractile	Form fibres that when contracted (shortened) can bring about the movement of the body.		

1.1R Protein Function

Protein function depends on structure

Carrier proteins play an important part in *transport across membranes*, e.g. Na/K pumps are globular proteins with binding sites which recognise and transport ions across nerve cell membranes in preparation for transmission of an action potential.

Fibrinogen and **prothrombin** are *protective proteins* essential for the clotting of blood by forming the fibres making the 'network' of a scab.

Haemoglobin transports oxygen inside red blood cells:

- four chains can move to cause co-operative binding of oxygen;
- inside region of each subunit provides ideal environment for oxygen to bind to haemoglobin;
- outside of each subunit has charged R groups to help solubility of haemoglobin in cytoplasm.

In **Sickle cell disease**, a mutation causes a change in haemoglobin shape. The molecules stick together under acidic conditions and the red blood cells take on a 'sickle' shape.

Opsin is a part of the light-sensitive pigment *rhodopsin* found in rod cells of the retina.

Collagen is the most abundant of all animal proteins. It is found in the connective tissue of skin, tendons and ligaments.

- the long fibres provide a 'framework' for tissues (like iron in reinforced concrete);
- presence of glycine allows three chains to pack together, giving strength to the molecule;
- side chains of other amino acids are hydrophobic, so the molecule is insoluble in water.

In **Scurvy**, lack of vitamin C means that the hydrogen bonds do not form properly. The collagen weakens so skin lesions (tears) occur and the teeth fall out from the gums.

Any mutation which causes glycine to be replaced with a different amino acid means that the triple helix cannot pack properly and becomes weakened. This happens in **osteogenesis imperfecta** - collagen in bones is unstable and bones become brittle.

1.1P Protein Structure

The four levels of protein structure

Individual amino acids are joined together by **peptide bonds** by **condensation reactions** catalysed by enzymes. Hydrolysis occurs here during digestion.

CONH is a very important linkage referred to as **peptide linkage.**

Successive condensations produce a linear chain of amino acids: this **sequence of amino acids** represents the **primary structure of the protein**. This primary structure is maintained by **covalent bonds between adjacent amino acids.**

The polypeptide chains may take on regular arrangements called the **secondary structure** of the protein e.g. the **α-helix**. This secondary structure is maintained by **hydrogen bonds between the >C=O and >N-H groups of every fourth peptide link.**

An alternative secondary structure - the **β-pleated sheet** - has hydrogen bonds between peptide links of adjacent polypeptide chains. Proteins with a well-developed secondary structure are **fibrous proteins**. Examples are **keratin** in hair, **collagen** in skin and **fibrin** in blood clots.

Several **polypeptide chains** (**tertiary structures**) **may be fitted together** to produce the **quaternary structure of the protein.** The stability of the quaternary structure is maintained by **weak interactions between -R groups of adjacent polypeptide chains** and by **Van der Waal's forces between subunits.**

The relative movement of the polypeptide chains may be critical to the function of the protein. The oxygen transporter **haemoglobin** is an example of a protein with a quaternary structure.

Sections of α-helix may be folded on themselves: this **supercoiling of the α-helix** represents the **tertiary structure of the protein**. This three-dimensional shape or **conformation** of the protein is maintained by a **series of interactions between -R groups on the polypeptide chain.**

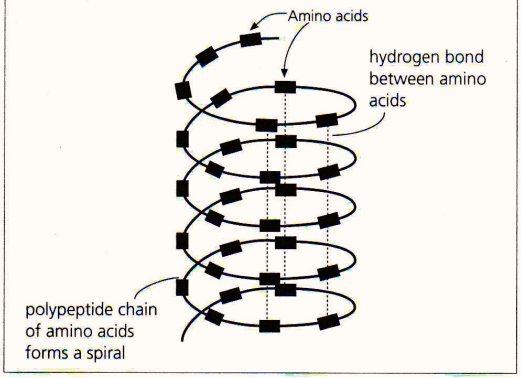
These interactions are very weak so that the conformation of such globular proteins can be easily altered by local physical changes - these alterations are reversible and are essential for the biological function of these molecules. Proteins with a well-developed tertiary structure are **globular proteins**. Examples are **enzymes**, **regular molecules** in membranes and **serum albumin**.

T 2 Shapes of protein molecules

Look up the structure of amino acids and formation of peptide bonds (see CAMS *Biology Core* book page 10, Fig. 7). In different amino acids, the R-group is different, for example in alanine it is CH_3. Some amino acids contain the element sulphur. A protein molecule is made up of a long chain of amino acids joined together by peptide bonds. The chain is called a polypeptide. The sequence of amino acids is called the **primary structure** of the protein. The genetic information carried in DNA determines the primary structure.

But proteins are three-dimensional structures, not flat chains. They form complicated shapes due to the linking together of different amino acids, each with its own shape. The amino acid chains produce spirals, with hydrogen bonds forming between twists in the spiral. This helical structure of a protein is called the **secondary structure** (Fig. 1).

Fig. 1 Secondary structure of a protein



Different spirals of amino acids link together in different ways, to give a range of polypeptides with different functions. **Fibrous** proteins form when these spirals join together to form long threads, such as keratin, a protein found in hair. Most proteins, however, form irregular-shaped structures, called **globular** proteins. Enzymes and proteins found in cell membranes are globular proteins. The way that the amino acids twist and turn to form the globular shape is caused by the way in which the amino acids in the chain attract or repel each other. The overall shape of a protein molecule is called its **tertiary structure** (Fig. 2). Where the chain twists and folds around itself, chemical bonds form between amino acids that come close to each other. Three types of bond can form (Fig. 3).

Fig. 2 Tertiary structure of a globular protein

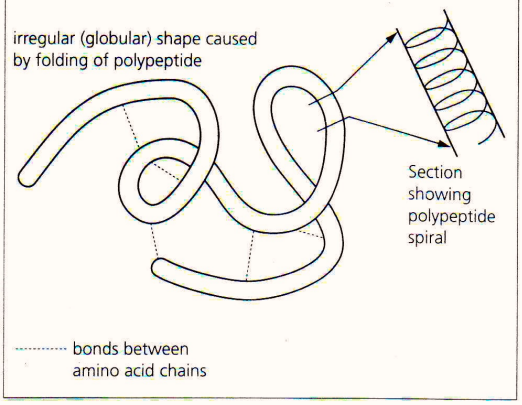
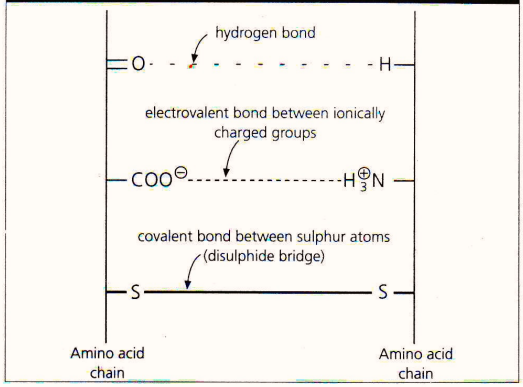


Fig. 3 Chemical bonding in a protein molecule



The main group of globular proteins are enzymes. Enzyme molecules need to have a particular shape, so that they can link with the right substrate molecules for the reactions they catalyse. A mistake during protein synthesis could mean that the wrong amino acid is inserted into the protein molecule. This would produce an enzyme with a different shape. The new shape may mean that the enzyme and substrate do not fit together, and the reaction is not catalysed.

Some proteins consist of several polypeptide chains linked together, such as haemoglobin, which is made up of four separate polypeptide chains. The linking of polypeptides in a protein produces a **quaternary structure**.

© HarperCollins*Publishers*

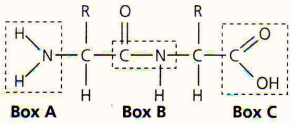
Questions

Q1 Match the following aspects of the structure of a protein molecule with the correct description:

a Primary structure.
b Secondary structure.
c Tertiary structure.
d Quaternary structure.

A The coiling of an amino acid chain into a spiral structure.
B The association of several polypeptide chains.
C The sequence of amino acids in a polypeptide chain.
D The irregular folding of a polypeptide chain into a globular shape.

Q2 The diagram shows a dipeptide.



a Show, by means of a similar drawing, one of the two amino acids produced by hydrolysis of this dipeptide.
b What is the name of the chemical group represented by Box A?
c What is the chemical group represented by Box C?
d What is the name of the chemical bond shown in Box B?

Q3 The tertiary structure of a protein is held in place with chemical bonds.

a Give the name of one chemical bond that is present in the tertiary structure of a protein, but not in the secondary structure.
b Name a chemical bond present in both the tertiary structure and the secondary structure.

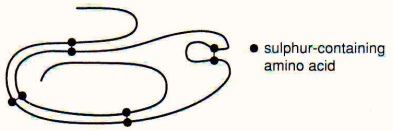
The tertiary structure is important in determining the shape of a protein molecule.

c Explain why a mistake leading to the insertion of the wrong amino acid during protein synthesis could produce an enzyme that does not function.
d Why do enzymes no longer function if heated to a temperature of 80 °C?
e Glucose, and no other sugar, is transported into cells by protein carrier molecules in the cell-surface membrane. How do the carrier molecules specifically recognise glucose?

Q4 The enzyme RNAase is a protein containing 124 amino acids.

a Assuming that there are 20 different amino acids involved in protein structure, how many different sorts of protein molecule could be made containing 124 amino acids?
b Explain what causes the sequence of amino acids in molecules of RNAase to be the same each time they are made.

The diagram shows the tertiary structure of a molecule of RNAase.

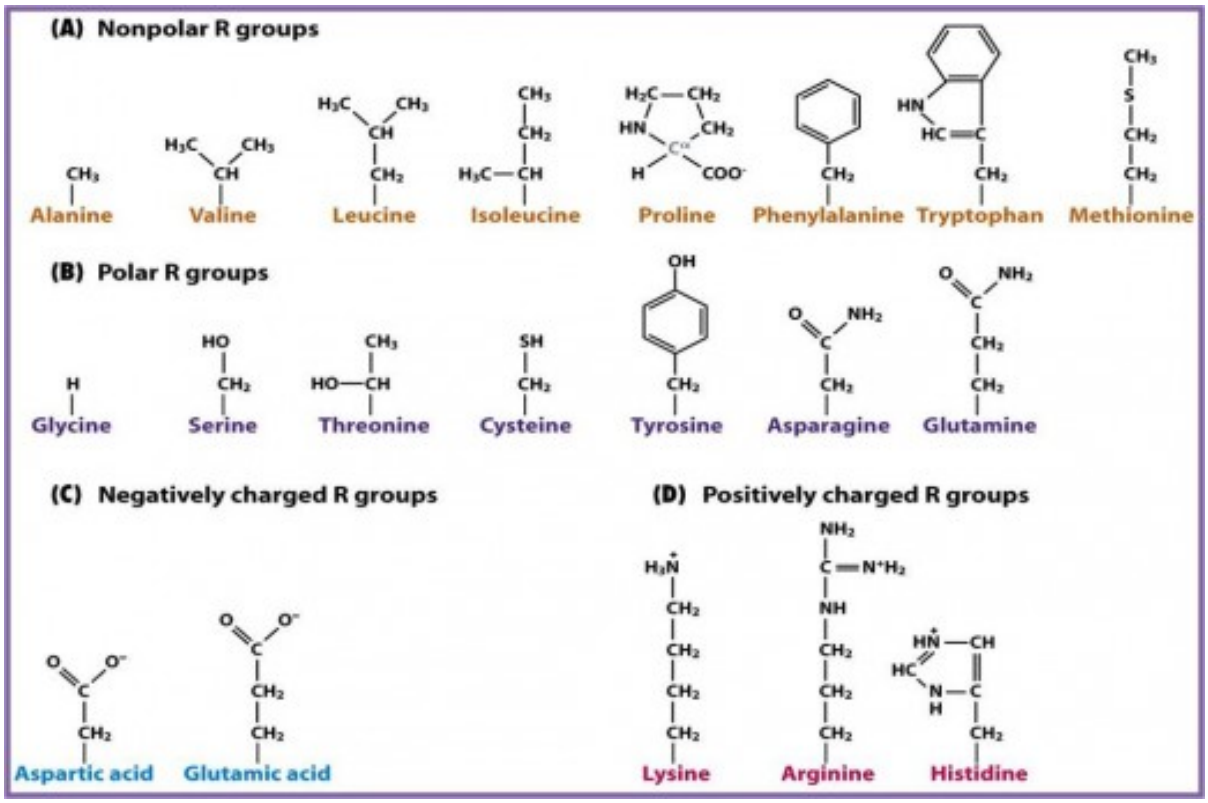


c Apart from involving different amino acids, in what way do the two ends of the RNAase molecule differ from each other?
d Explain why all molecules of RNAase have the same tertiary structure.
e Urea breaks hydrogen bonds and the substance mercaptoethanol breaks disulphide bridges. If a molecule of RNAase were treated with a mixture of urea and mercaptoethanol, explain what would happen to:
– the structure of the RNAase;
– its enzyme activity.

© HarperCollinsPublishers

1.1 Page 5 – Proteins

1. Below is a diagram showing the R groups of different amino acids.



Draw the following:

i. The amino acids Cysteine and Methionine, highlight the carboxylic (acidic) groups and the amino (basic) groups.
ii. Condensation reaction between Valine and Glutamine
iii. Hydrolysis of a dipeptide formed from Glutamic acid and Glycine.

2. Define primary structure. Why is the primary structure significant?

3. How is the secondary structure of a protein achieved from the primary structure? How is the shape maintained?

4. What is the name of the most common secondary structure?

5. Give some examples where the specific shape of a protein is critical.

6. How is the tertiary structure of a protein achieved from the secondary structure? How is this shape maintained?

7. Do all proteins have a well-developed tertiary structure?

8. R- groups will project from a proteins tertiary structure. In which direction do you think hydrophobic / non-polar R groups will face in a globular and a fibrous protein?

9. Define quaternary structure. Give an example of a protein which exhibits this level of structure.

Bio Factsheet

Number 80

Structure and Biological Functions of Proteins

By studying this Factsheet the student should gain knowledge and understanding of:

- **The primary, secondary, tertiary and quarternary structure of proteins, including fibrous and globular types.**
- **The effect of pH on amino acids and proteins.**
- **Denaturation by extremes of pH or temperature.**
- **The biological functions of proteins, enzymes, hormones, carriers, membrane proteins, including structural, contraction, protection (antibodies), osmotic and buffering roles.**

For a full description of the chemical bonds referred to in this Factsheet the student should refer to Factsheet No.78, September 2000, Chemical Bonding in Biological Molecules.

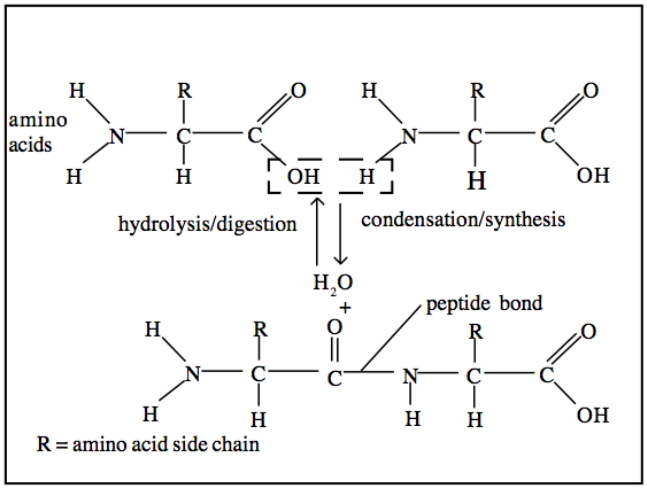
Remember *- amino acids are made in autotrophic green plants as products of photosynthesis, and then are assembled into proteins. Heterotrophic organisms gain their amino acids and proteins from plants through food chains in the case of animals, or in decay processes in the case of bacteria and fungi.*

The structure of proteins

Twenty types of amino acid occur which form the 'building blocks' of proteins. Amino acids join together by peptide bonds, formed by condensation between the acid group of one amino acid and the amine group of the other amino acid (Fig 1). When two amino acids join in this way the product is a dipeptide. Many amino acids joined in this way make up a polypeptide.

Remember *- condensation is the joining of molecules by the removal of water and is used in many synthetic processes. The reverse process is hydrolysis which is the splitting of molecules by the addition of water and is used in digestion.*

Fig 1. Formation of a peptide bond between two amino acids



More amino acids can join by peptide bonds onto the ends of the dipeptide resulting in the formation of a polypeptide. The polypeptide with its specific sequence of amino acids is called the 'primary structure of the protein'.

Remember *- the sequence of amino acids in the polypeptide is governed by the sequence of codons in the gene that assembles that polypeptide by using the messenger RNA/transfer RNA/ribosome mechanism.*

The polypeptide chain is folded to make particular three dimensional shapes known as the 'secondary structure of the protein'. These shapes may either be of the alpha-helix type or the beta-pleated-sheet type. They are characteristic of fibrous type structural proteins. The secondary structure may be further folded tightly to give the 'tertiary structure of the protein'. This is characteristic of globular type proteins such as enzymes and antibodies. Secondary and tertiary structures are still single polypeptides. The 'quaternary structure of a protein' is the way in which polypeptides (in secondary or tertiary form) join together to form proteins.

The secondary, tertiary and quaternary structures are not loosely, randomly folded structures but are precisely shaped and cross-bonded by ionic, hydrogen, sulphur and peptide bonds. These are formed between reactive groups in the amino acid side chains. (The core acid and amine groups of the amino acids are already involved in joining the amino acids by peptide links). Figs 2 and 3 show three dimensional forms of secondary, tertiary and quaternary polypeptides and protein molecules.

Fig 2. Three dimensional forms of polypeptide- Secondary structures

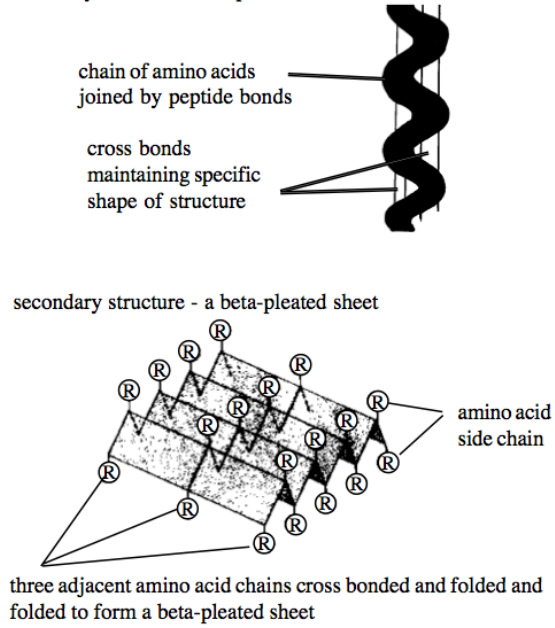


Fig 3. Three dimensional forms of polypeptide and protein molecules - Tertiary and Quaternary

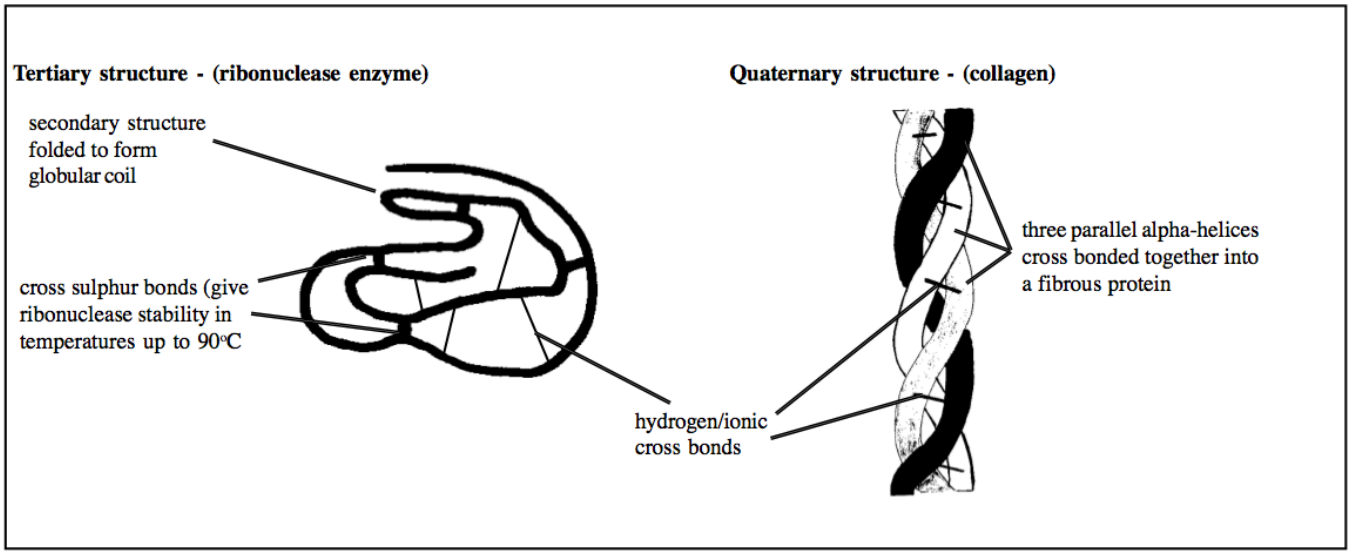
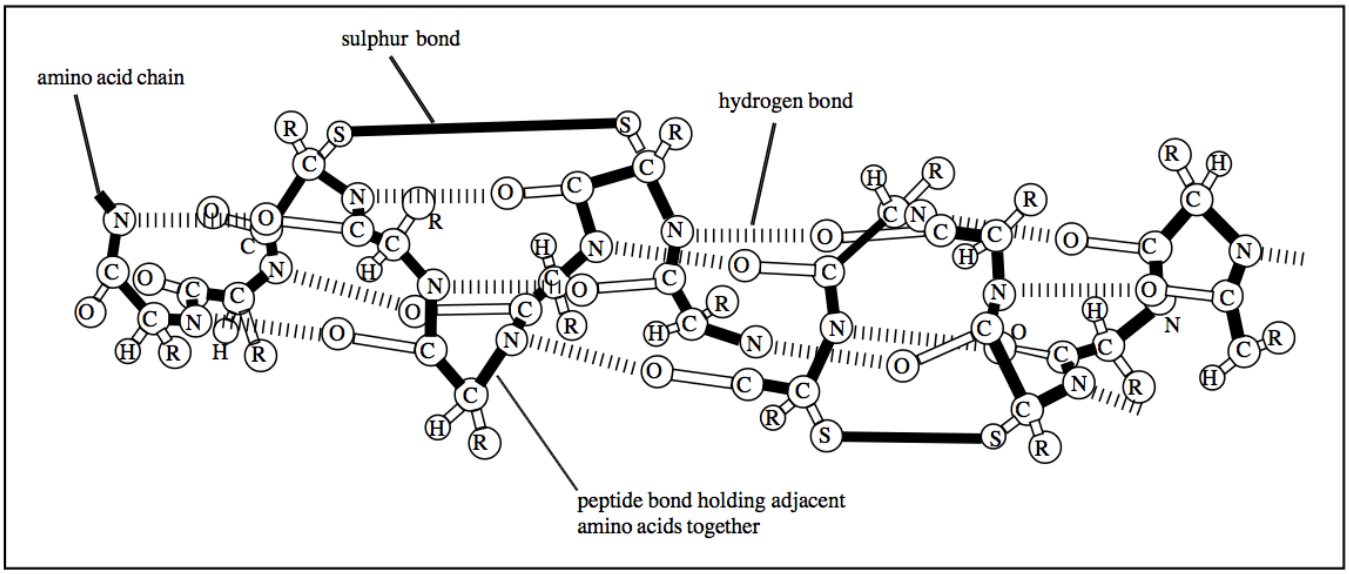


Fig 4 shows the structural formula of an alpha-helix.

Fig 4. Structural forms of an alpha-helix



Types of protein

In addition to being classed as fibrous or globular forms according to their 3D structure, proteins may be classed as **simple** or **conjugated**. Simple proteins only contain amino acids in their structure and exist as several different types, such as albumins, globulins and scleroproteins. Examples of these types will be named later. Conjugated proteins contain amino acids plus some other type of chemical molecule, such as nucleic acids in nucleoproteins, phosphoric acid in phosphoproteins and lipids in lipoproteins. Haemoglobin is a conjugated protein consisting of four globular polypeptides each of which contains a porphyrin ring which also contains iron.

The effect of pH on amino acids and proteins

The pH measures the hydrogen ion concentration of the medium in which the amino acid or protein is, whether, for example, in blood, tissue fluid, cell, animal or plant or soil. The hydrogen ion concentration will affect how the amino acids and proteins ionise. The acid and amine groups of amino acids ionise as shown in the equilibrium reactions:

1. $R.COOH \rightleftharpoons R.COO^- + H^+$ and 2. $R.NH_2 + H^+ \rightleftharpoons R.NH_3^+$

Thus, in a high hydrogen ion concentration (acid pH) reaction 1 will tend to be pushed to the left and reaction 2 will tend to be pushed to the right. The amino acids will therefore be predominately positively charged **cations**.

In a lower hydrogen ion concentration (less acid or alkaline pH) reaction 1 will tend to proceed to the right and reaction 2 will tend to proceed to the left. The amino acids will therefore be predominantly negatively charged **anions**.

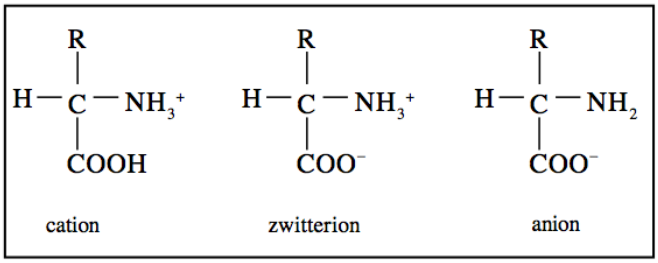
There is an intermediate hydrogen ion concentration where the forward and backward rates of reactions 1 and 2 are equal (50:50). The amino acids will then carry 50% of amine groups charged and 50% of amine groups uncharged, 50% of acid groups charged and 50% of acid groups uncharged. Such ions are called **zwitterions** (German for 'ions of two types). The pH at which this occurs is a physical constant for each specific amino acid or protein and is called the **iso-electric point (IEP)**.

Remember *– the iso-electric point is the pH at which the amino acids or protein carry no net charge/carry equal amounts of negative and positive charges.*

Exam hint *– a common omission when defining 'iso-electric point' is to fail to refer to pH . Candidates often just say 'the iso- electric point is the point at which the protein carries no net charge'. Candidates also often incorrectly say that the IEP must be pH 7.*

Proteins behave in a similar way to amino acids but the charges are on acid, amine and hydroxide groups in the amino acid side chains – the core amine and acid groups are bound up in the peptide bonding. The ionic state of amino acids is shown in Fig 5.

Fig 5. Ionic states of an amino acid



The charges on a protein resulting from the pH effect may have an influence on its behaviour:

- the charges on the active sites of an enzyme may affect the capability of the enzyme to join with its specific substrate. This is why enzymes tend to work best at specific pHs.
- at the IEP the protein carries equal numbers of opposite charges. Opposite charges attract which may make the protein molecules clump together and precipitate. At other pHs the protein only carries like charges. These repel molecules from each other and thus may increase the solubility.
- at extremes of pH the protein molecules may carry huge numbers of like charges as reactions 1 and 2 go almost to completion. These charges may exert a large repulsive force which breaks apart the hydrogen and ionic bonds holding the 3D structure together. The 3D structure therefore breaks apart and the protein is denatured since its structure and functional ability is lost

Remember *– denaturation is the loss of function of a protein caused by a loss of structure. Another agent of denaturation may be heat. This can disrupt the hydrogen and ionic bonds thus causing the 3D structure to unravel. Most proteins denature around 45°C. Sulphur bonds are more stable to heat and thus proteins with many such bonds can withstand higher temperatures. e.g. enzymes in bacteria which live in hot springs and ribonuclease in saliva.*

The range of biological functions of proteins

- **structural proteins**: Many structural proteins belong to the class of scleroproteins. Examples are;
  - **collagen** – found as strong non-elastic white fibres in tendons, cartilage and bone.
  - **elastin** – found as yellow elastic fibres in ligaments and joint capsules.
  - **keratin** – found as a horny impermeable protein in skin, hair, feathers, nails and hooves.

  Other structural proteins are the **lipoproteins** of cell membranes, **viral coat proteins**, **fibroin** found as spider silk and cocoon silk, **sclerotin** found in insect exoskeletons, and **mucoproteins** found in lubricating joint (synovial) fluid.

- **enzymes**: syllabus examples are **hydrolases** such as amylases, proteases and lipases used in digestion, **oxido-reductases** such as the dehydrogenases used in the metabolic cycles and **ligases** which enable molecules to be bonded together using the energy from ATP.

- **hormones**: some hormones are protein in nature, such as **somatotropin** – pituitary growth hormone and **insulin** which regulates blood glucose concentrations.

- **contractile proteins**: some proteins can contract and lengthen and thus enable movement. Examples are **actin** and **myosin** found in muscles and **dynein** making up the structure of cilia and flagella.

- **storage proteins**: because of their toxic amine groups, amino acids cannot be stored, unless they are bound within protein structure. Examples are **ovalbumin** or egg white protein, **casein** and **lactalbumins** which are milk proteins, **glutelins** and **gliadins** which are cereal seed proteins and **ferritin** which binds up iron and stores it in the spleen, liver and red bone marrow.

- **transport proteins**: bind on to and release insoluble or inadequately soluble substances so that they can be transported through the body. Examples are **haemoglobin** for oxygen transport in vertebrate blood, **myoglobin** for oxygen transport in muscles, **plasma albumin** which transports fatty acids in blood, **transferritin** which transports iron through blood to the iron storage sites and **binding globulins** which transport insoluble thyroid hormones through blood.

- **protective proteins**; examples are the blood clotting factors such as **thrombin** and **fibrinogen** which reduce bleeding during injury, **antibodies** (gamma globulins) which can react with foreign proteins (antigens) to neutralise them, thus giving protection against disease, and **complement** which can form complexes with antigen-antibody systems enhancing their activity.

- **buffers**: many amino acids and proteins have buffering ability and thus reduce pH change within the organism. A classic example is **haemoglobin** which can react with hydrogen ions forming **reduced haemoglobin**. This buffers the blood between pH 7.2 and 7.6.

- **osmotic proteins**: **plasma albumin** in blood is responsible for much of the osmotic pressure or water potential of blood, which tends to hold water in the blood plasma thus maintaining the blood volume. Proteins in most biological fluids, such as cell sap in plant cells and in invertebrate bloods, have a similar role.

- **toxins**; some proteins act as toxins or poisons. Examples are the **phospholipase** enzymes found in many snake venoms – these destroy cell membranes. Many bacteria such as **Clostridium tetani**, **Clostridium botulinum** and **Diphtheria**, release toxic chemicals that are very dangerous to humans. **Ricin** is a toxic chemical that is found in castor oil beans which if taken, in contaminated castor oil, causes jaundice, gastrointestinal problems and heart failure.

Exam hint – questions on functions of protein may often require continuous prose or essay type answers. Make sure that you can illustrate your answers by reference to specific examples for each function.

Specimen Questions

1. Read through the following account of protein structure and then complete the passage by writing in the most suitable word or words in the spaces.

Amino acids join together into polypeptide chains by ..... bonds which are formed by ..... reactions. The linking bonds are formed between the ..... and ..... groups of the amino acids when ..... is released from the reaction.
The polypeptide chains may be folded into secondary structures, such as the ..... and ..... . Secondary structures may be further folded into tertiary structures, such as the ..... . Polypeptides are combined together to give the ..... structure of the protein. These three dimensional shapes of the protein are held firmly in place by ionic bonds, ... bonds and covalent ..... bonds. Disruption of these bonds, by extremes of pH or exposure to ..... causes ..... of the protein.

Total 13

2. Suggest reasons for the following observations:
   (a) Proteins may precipitate at certain pHs but be soluble at other pHs. 4

   (b) Casein precipitates at pH 4.7 but lysozyme precipitates at pH 11.0. 3

   (c) Most enzymes denature around 45°C but ribonuclease does not denature until 90°C. 3

Total 10

3. Complete the following table which concerns proteins and their functions. Give one example only in each case.

Function	Example
Forms a waterproof hard layer on skin surface.	
Forms a foodstore in cereal grains.	
Enables joint capsules to stretch.	
Transports iron through blood	
Can regulate growth in mammals.	
Forms strong fibres in muscle tendons.	
Holds oxygen in muscles.	
Can join molecules using energy from ATP.	
Combines with antigen-antibody debris.	
Makes cilia mobile.	

Total 10

Answers

1. peptide; condensation; acid/amine;; water; alpha helix/beta pleated sheet;; globular/coil/type/shape; quaternary; hydrogen; sulphur; high temperatures; denaturation;

Total 13

2. (a) different proteins have different iso-electric points;
   at the IEP equal numbers of opposite charges attract;
   thus protein molecules clump together and precipitate;
   at other pHs all charges are similar and so repel, preventing clumping and precipitation; 4

   (b) the IEP of casein is probably pH 4.7 and that of lysozyme is probably pH 11.0;
   proteins are most likely to precipitate at their IEPs;
   due to carrying equal numbers of attracting opposite charges; 3

   (c) most enzymes are bonded together by mainly ionic and hydrogen bonds;
   these are very susceptible to disruption by heat/are not heat stable;
   ribonuclease contains many sulphur bonds which are heat stable; 3

Total 10

3.

Function	Example
Forms a waterproof hard layer on skin surface.	**keratin;**
Forms a foodstore in cereal grains.	**glutelins/gliadins;**
Enables joint capsules to stretch.	**elastin;**
Transports iron through blood	**transferritin;**
Can regulate growth in mammals.	**somatotropin;**
Forms strong fibres in muscle tendons.	**collagen;**
Holds oxygen in muscles.	**myoglobin;**
Can join molecules using energy from ATP.	**ligase (enzyme);**
Combines with antigen-antibody debris.	**complement;**
Makes cilia mobile.	**dynein;**

Total 10

Acknowledgements;
This Factsheet was researched and written by Martin Griffin
Curriculum Press, Unit 305B, The Big Peg, 120 Vyse Street, Birmingham. B18 6NF
***Bio Factsheets** may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.*
ISSN 1351-5136